CEMENT AND LIME MANUFACTURE

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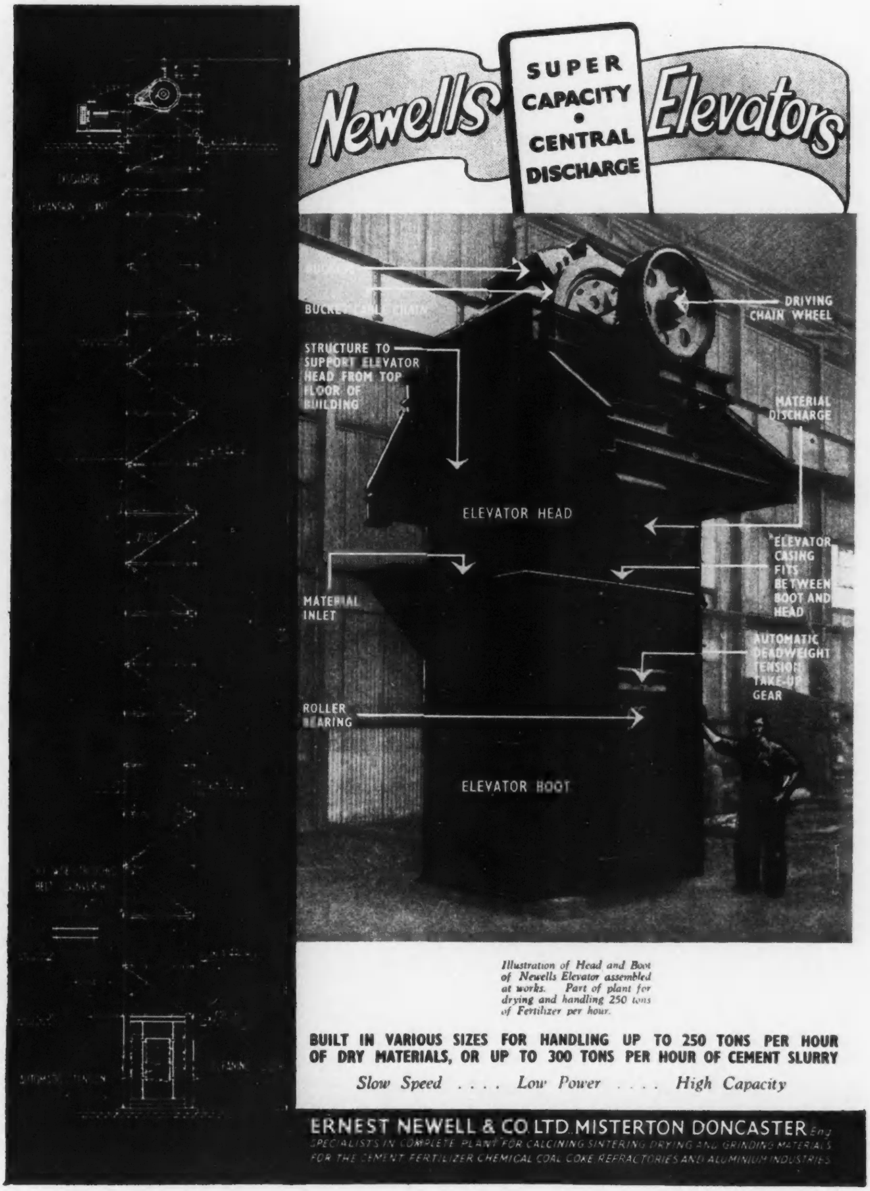
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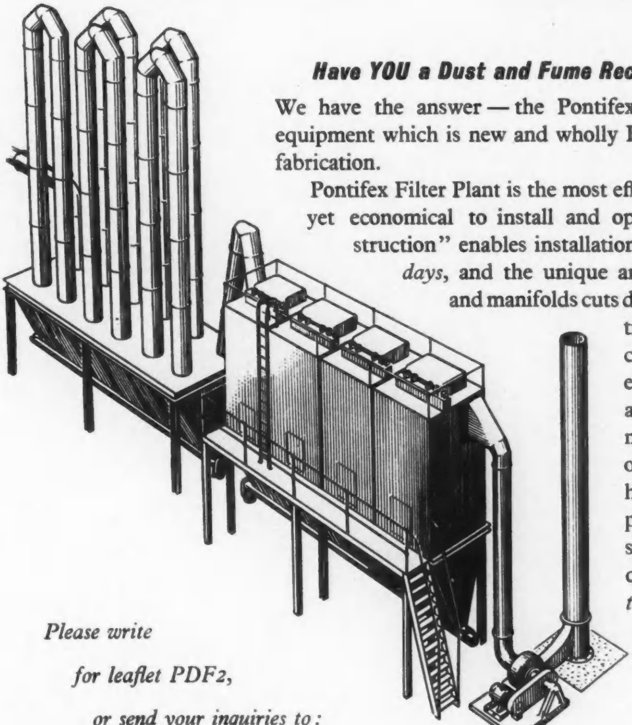

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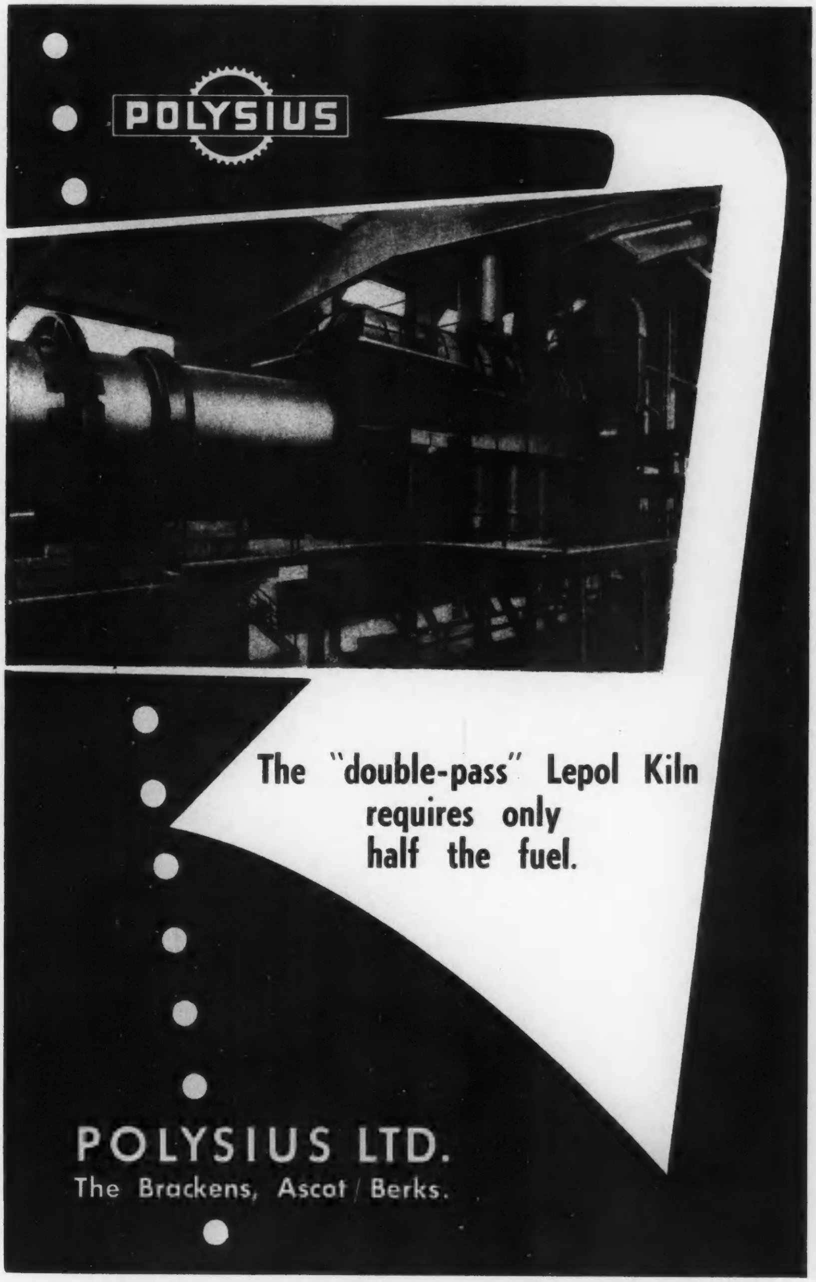
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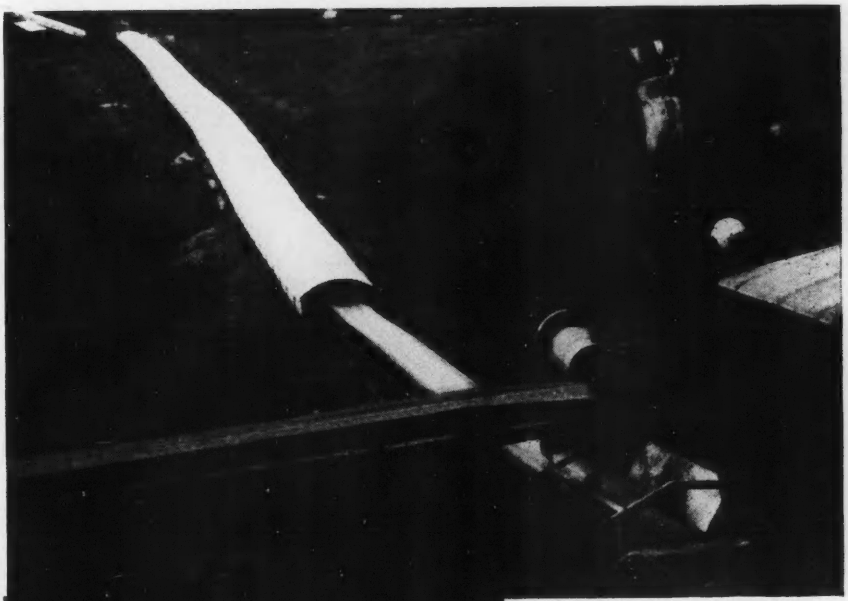

We illustrate the use of our conveying equipment for handling shale at the new cement works of British Portland Cement Manufacturers Ltd., at Cauldon, Staffs. The 48-in. belt-feeder, illustrated above, delivers the shale to the 36-in. belt-conveyor which takes it to the hopper of the crushing plant.

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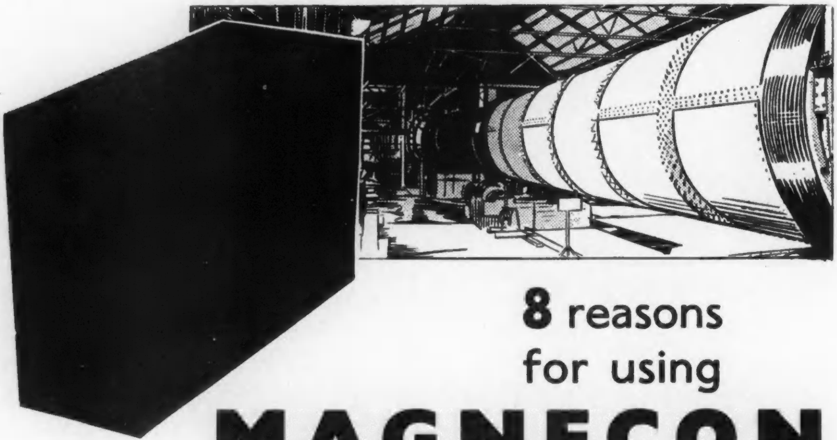

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New Cement Works in Staffordshire.

A "DRY-PROCESS" WORKS.

A new works at Cauldon, Staffordshire, of the Blue Circle Group of cement companies started production at the end of April last. *Fig.* 1 is an aerial view of the works. A plan and a flow sheet are given in *Figs.* 2 and 3. The annual capacity is about 200,000 tons. The raw materials are available close to the works and consist of shale (of the Carboniferous age) and carboniferous limestone which dips beneath the shale. Four parts of limestone are used to one part of shale, with the addition of 1 per cent. to 1½ per cent. of iron oxide.

Preparation of Limestone.

The limestone is excavated by a face-shovel of 2½ cu. yd. capacity after drilling and blasting, using a diesel-driven blast-hole drill and a pneumatic drifter-drill mounted on a wagon. The face-shovel loads three diesel-driven dumpers, each of 9 cu. yd. capacity, which deliver the material to the crushing plant.

The crushing plant is in a reinforced concrete building which is planned for an output of 450 tons an hour; the primary crusher and its ancillaries are capable of this output, but only half of the secondary crushing plant has been installed so that the present capacity is 225 tons an hour.

Stone is tipped from the dumpers into a hopper over a pan-feeder driven by a variable-speed 30/10-h.p. motor. The hopper discharges to a 42-in. gyratory crusher (driven by a 250 h.p. motor) which reduces stone from 36 in. to 6 in. and delivers it to a 42-in. belt-conveyor rising to the top of a surge-bunker of 70 tons capacity. From one of the two outlets of this bunker a vibrating feeder extracts stone on to a 36-in. belt-conveyor which delivers it to the secondary crusher; the entry of tramp iron is prevented by a magnetic pulley at the top of the conveyor.

The secondary crusher is a 5½-ft. cone machine with an output of 225 tons per hour of stone smaller than 1¼ in. and is driven by a 200-h.p. motor. The product passes to two double-deck horizontal screens having top screens of 1¼ in.

square mesh and blank bottom decks; the oversize material is returned to the 42-in. belt-conveyor for recrushing, while the fines pass from the bottom decks to a 36-in. belt-conveyor 1,500 ft. long which delivers to one of four compartments of the limestone bunker by a travelling tripper having a reversible transverse conveyor. The openings extend the full length of the compartments, and where they are not occupied by the conveyor chutes they are closed by a travelling rubber cover. A dust-collecting plant with a capacity of 13,500 cubic feet of air per minute is installed in the building.

The stone is stored in a four-compartment reinforced concrete bunker with a capacity of 6,000 tons; each compartment has one outlet.

Preparation of Shale.

Shale is dug by an electric face-shovel of 1½ cu. yd. capacity operating on a 415-volt supply. It is dumped into a movable hopper from which it is delivered by a 48-in. belt-feeder on to a 36-in. belt-conveyor and thence to another 36-in. belt-conveyor which supplies the hopper of the crushing plant. The second conveyor is equipped with an electronic metal detector, which, on detecting a piece of tramp metal (ferrous or non-ferrous), sounds a horn and stops the conveyor system.

A steel-plate apron-feeder 54 in. wide passes the shale from the hopper to a hammer-mill, which has moving breaker and back plates and is especially suitable for sticky materials; it is capable of reducing shale from 12 in. to less than ¾ in. at a rate of 150 tons an hour, and can accept occasional lumps up to 30 in.; it is driven by a direct-coupled motor of 300 h.p. operating at 730 revolutions a minute. A circular-type dust-filter with a capacity of 11,000 cubic feet per minute is installed to produce a down-draught through the mill.

The crushed shale is discharged on to a 60-in. flat belt-conveyor, which also collects droppings from the apron-feeder. It is then discharged on to a 24-in. troughed belt-conveyor which takes it to the top of the shale store, where it is distributed over the full length of the store by a reversible shuttle conveyor, and subsequently trimmed by an electric overhead travelling grabbing crane, with a capacity of about 4 tons, over the length of the store; the storage capacity is 1,500 tons. Four outlets are provided in the bottom of the shale store.

Storage of Raw Materials.

The iron oxide is tipped by lorries into a pit from which it is transferred by grab either to a store with a capacity of 150 tons or to the feed bunker with a capacity of 280 tons gross and with two discharge openings.

Gypsum is tipped from road vehicles into a hopper from which a 24-in. belt-conveyor delivers it to an elevator with a capacity of 60 tons an hour; this discharges into the gypsum store, which has a capacity of 1,170 tons.

Coal is delivered by road and tipped within the covered coal store, which has reinforced concrete walls and a capacity of 3,000 tons. The coal is spread by a bulldozer to a depth of 15 ft., and is delivered from the store to a hopper at ground level whence a 20-in. troughed belt-conveyor conveys it to a 30-in. by 28-in.

Fig. 1. Aerial View.

double-roll crusher capable of crushing 60 tons per hour to $\frac{3}{4}$ in.; a magnetic separator situated over the conveyor removes any tramp iron. The crushed coal falls into the boot of a bucket elevator, which delivers it to a 20-in. troughed belt and 36-in. flat belt with knife gear, which take it to a bunker of 250 tons capacity.

Grinding and Blending Raw Materials.

The raw materials are dried and ground in a development of an airswept edge-runner mill, the product being recovered in a combined mechanical and electrostatic collector. There are two separate grinding units, each capable of independent operation and consisting of feed, grinding, and collection groups. The shale is

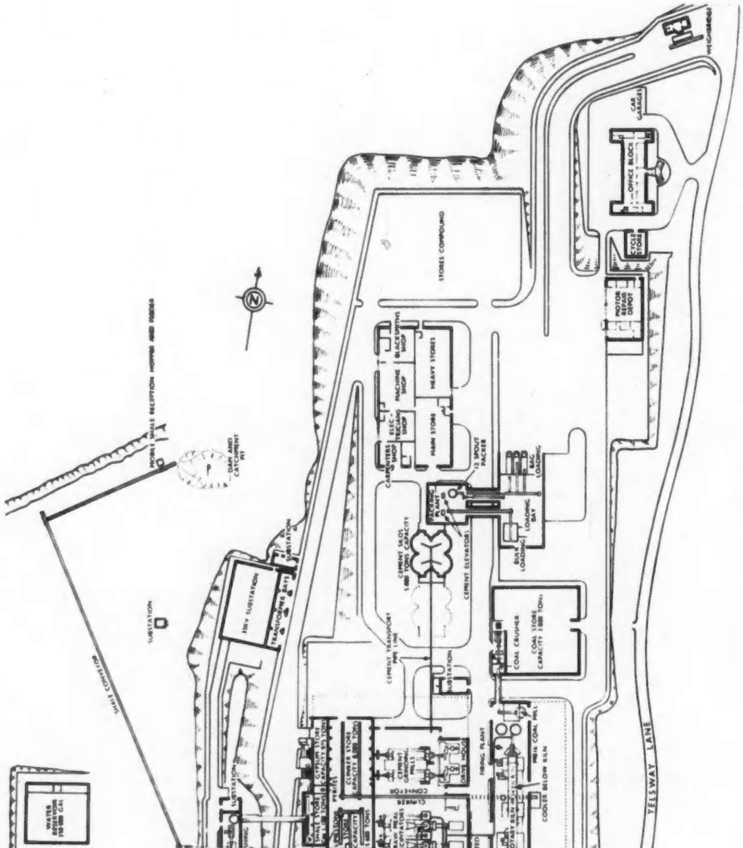

Fig. 2. Plan of Works.

extracted from the bunker by an apron-feeder 36 in. wide, with a variable-speed drive. The limestone is delivered by two vibratory-feeder units per mill, the output of each being variable between 5 tons and 35 tons per hour. The iron oxide is extracted from the bunker by an apron-feeder 28 in. wide at 3 ft. 6 in. centres; in order to give the slow speed required for delivering one-third ton to 2½ tons per hour a ratchet mechanism is incorporated in the drive. From these conveyors the materials are delivered to a 20-in. belt-conveyor which transports them to an elevated hopper with a capacity of 34 tons. One side of this hopper is supported on an hydraulic load cell which is connected to a gauge calibrated to indicate the contents of the hopper in tons; adjustable contacts are provided in the gauge to stop and start the four feeders. By this means sufficient depth of material is provided in the hopper to ensure that the feed to the mill is adequately sealed against the high suction within.

The materials are extracted from the hopper by two vibratory feeders, the amplitude of vibration being regulated according to the suction within the mill. The mill is 28 ft. high to the top of the casing and 15 ft. diameter at the base, and it weighs 125 tons. It is driven through a gear-box by a 500-h.p. motor, and a 27-h.p. motor drives the classifier in the upper part of the machine; motor-driven barring gear is also included for starting and maintenance purposes. Each mill is capable of drying and grinding 35 to 40 tons per hour to leave 6 per cent. residue on a 170-mesh sieve. Hot air for each mill is provided by a separate furnace fired with pulverised fuel; the coal, which is produced in the kiln-coal crushing plant, is blown through about 270 ft. of 9-in. pipe to the furnace. The consumption is 2½ per cent. of standard coal to clinker when grinding limestone with 5 per cent. moisture content and shale with 20 per cent. moisture content. The supply of hot air to the mill is automatically regulated in quantity and temperature, and cold air is automatically supplied should an excessive temperature be reached at the mill inlet.

The fine material produced in the mill is drawn upwards through the integral classifier, which rejects oversize material, and the fine material then passes to a mechanical pre-collector which, positioned immediately prior to an electrostatic precipitator, reduces the initial dust content of 263 grains per cubic foot to about a fifth of that value. The combined unit is designed to deal with 44,000 cubic feet of air a minute at a temperature of 160 deg. F. and is under suction from the 350-h.p. centrifugal fan; the total resistance of the mill, collector, and ducting is about 30 in. water gauge. The combined efficiency of the collector is 99·9 per cent.

The raw material falls into hoppers below the collectors of the two grinding units and is conveyed by 24-in. screw-conveyors to a single 13-in. conveyor, the delivery head of which rises to supply the intake hopper of a 10-in. pump operated by a 70-h.p. motor; this pump delivers the meal through an 8-in. pipeline to the top of the blending-storage plant. A continuous sampler is included in the pipeline.

The raw meal blending and storage plant comprises two welded-steel blending silos, 29 ft. diameter by 38 ft. 6 in. high, supported on grillages on top of four

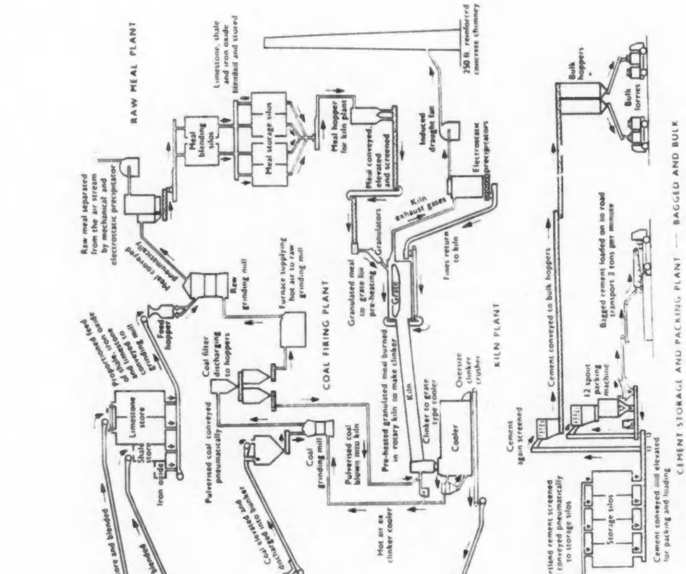

Fig. 1. Flow Diagram.

reinforced concrete storage silos of 29 ft. internal diameter by 37 ft. high. Each silo has a nominal capacity of 560 tons, representing the output of the two grinding units in a shift of eight hours. The blending silos are equipped with quadrant blending equipment, compressed air being supplied by rotary compressors. Four strain-gauge load cells are placed below each silo to give a continuous indication of the weight of the contents.

The material is delivered to the top of the blending silos through a valve which can be set to deliver to either silo, or alternatively automatically to distribute it to both silos by changing delivery at pre-selected intervals.

After blending, the meal is discharged by an airslide system to one or more of the storage silos below, which in turn are discharged by further airslides, which deliver to two 10-in. pumps. There are 8-in. pipelines from each pump to the elevated hopper in the granulator building, and under normal conditions one pump is used with the other as a stand-by; provision is also made for recirculation of the material from the pumps to any of the six silos. Two rotary compressors with 110-h.p. motors supply air to the pumps, whilst the low-pressure air for the airslides is provided by blowers. Continuous samplers are installed in the pipelines. For venting purposes the two blending silos are linked to the storage silos, which in turn exhaust through eight batteries of multiple-stocking-type filters.

Granulating Plant.

The granulating plant is in a building 116 ft. high. Apart from the large sieving screw, all the equipment between the hopper of 350 tons capacity and the feed-chute of the grate is in duplicate, both sets being in continuous service. From each of the two outlets of the kiln-feed hopper, a twin-screw extractor delivers to a 20-in. elevator which discharges into the sieving screw; the screw has an overflow airslide back to the hopper, thus maintaining a constant head of material over the dual star-feeders. These have variable-speed drives and each delivers to a vibratory conveyor of the "out-of-balance" motor type, which in turn discharges into one of the two dish granulators. The dishes are 12 ft. diameter by 3 ft. deep, and the inclination may be varied; crank-operated oscillating scraping-gear is provided.

Water is supplied to each granulator by a separate pump coupled to the variable-speed drive of the feeder; the quantity delivered is therefore directly proportional to the quantity of material, but since the pumps are of the variable positive-displacement type, the ratio of water to material may be varied to produce good nodules (*Fig.* 4). A moisture content of about 12 per cent. is found to give the best results. Rotameters are provided to indicate the rate of flow. A circular dust filter is installed in the granulator building.

The Grate.

The Lepol grate, 13 ft. wide and 71 ft. long between the centres of the head and tail shafts(*Fig.* 5), is of the double-pass type and is driven by a 17-h.p. variable-speed motor through a quadruple spur-reduction gear. Two induced-draught fans are provided, each driven by a 100-h.p. variable-speed motor;

the intermediate fan is at the side of the grate, and draws the gases from the first " pass " through six cyclones, which extract the clinker dust before returning the gases to the grate for the second " pass." The final induced-draught fan is placed between the electrostatic precipitator and the chimney.

Dust from the cyclones and riddlings from the grate are conveyed by screw-conveyors and drag-chain conveyors which deliver to elevators at each end of the grate plant; one of these elevators returns coarse material to the kiln feed-chute, while the other elevates the material to join the meal at the boots of the two meal elevators.

The Kiln.

The all-welded rotary kiln, by Vickers-Armstrongs (Engineers), Ltd., is 152 ft. long by 12 ft. 6 in. diameter inside the shell, and is carried on three tyres. The drive is adjacent to the tyre nearest the grate, the 90-h.p. variable-speed motor being coupled to a triple-reduction spur-gear (*Fig.* 6).

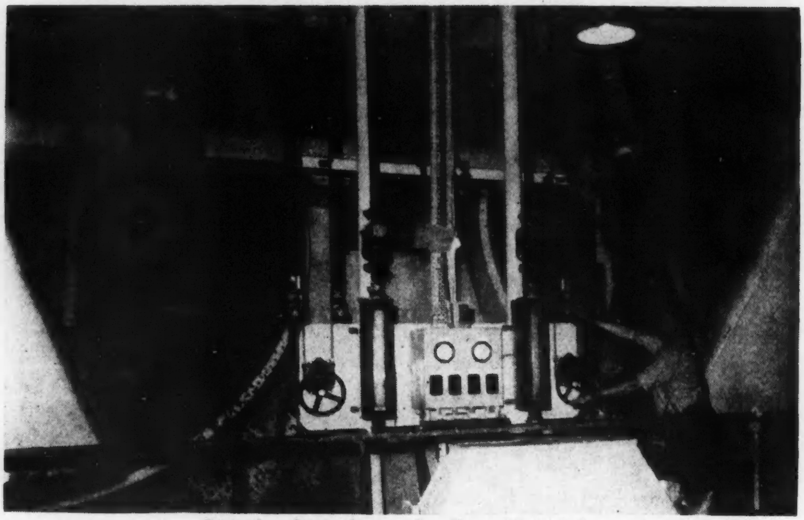

Fig. 4. Granulators for Raw Materials.

The guaranteed output of the grate and kiln is 500 tons per day and the standard proportion of coal consumption to clinker is 14 per cent. (663,000 B.t.u.'s per barrel).

The gases from the grate pass into an electrostatic dust precipitator, the reinforced concrete casing of which is divided longitudinally to provide two separate compartments, thus permitting maintenance of one without stopping the plant. The dust is conveyed by 12-in. screw-conveyors from the two collecting hoppers to a conveyor, which discharges into the dust-handling system of the grate. The precipitator is rated to deal with 65,000 cubic feet per minute at a temperature of 250 deg. F.; the lining is of blue bricks set in acid-resisting

mortar. The reinforced concrete chimney is 250 ft. high, and is suitable for use with three kilns; the lining and the top 15 ft. of the shaft are constructed of engineering bricks set in acid-resisting mortar.

The Cooler.

Clinker is discharged from the kiln into a double-pass grate cooler 7 ft. wide by 44 ft. long. Two 65-in. fans are provided, one for blowing cold air and the other for recirculation of air for the second pass; each has a 70-h.p. motor. The

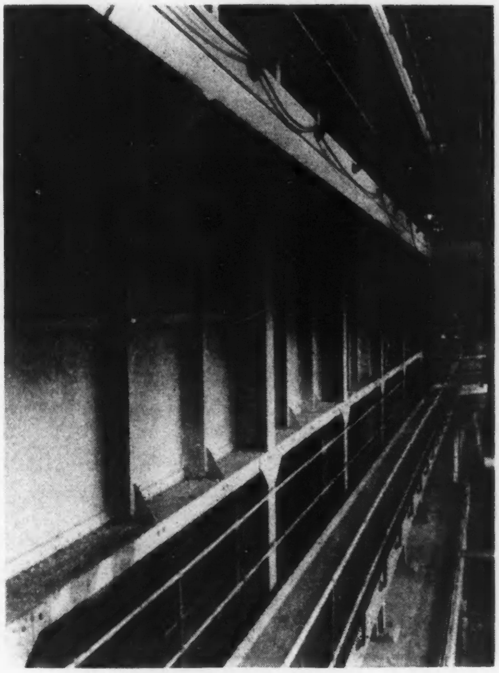

Fig. 5. Side of Grate.

cooler is capable of reducing the temperature of 700 tons of clinker per day to 170 deg. F.; the speed of the bed is varied by regulating the speed of the 12-h.p. motor driving the oscillating mechanism. Clinker from the cooler is conveyed by a drag-chain conveyor which also receives the fine material which falls through the grate; this conveyor delivers to a fully-troughed catenary conveyor which for most of its length rises at 30 deg. to the horizontal and discharges into a pair of conveyors which distribute the material over the length of the clinker store; the capacity of the store is 8,000 tons.

Cement Grinding.

Clinker and gypsum are extracted from the stores by belt-conveyors, those for the clinker being on rails so that each may be positioned to draw from any of three positions; the materials are carried to the mill inlet on a 20-in. belt-conveyor.

The two grinding mills have shells 45 ft. long by 8 ft. $4\frac{1}{2}$ in. inside diameter. Lining and diaphragms are fitted to form four chambers, and the total operating weight of each mill is about 170 tons. The mills are driven at a speed of $20\frac{1}{2}$ revolutions a minute by 1,200-h.p. motors through double-reduction helical gears. Each mill has an output of about 30 tons per hour when grinding ordinary Portland cement. From each mill the cement passes over a vibratory screen to a 7-in. pump which delivers to the silos. The pumps have 70-h.p. motors, and air is provided by two rotary compressors each with 90-h.p. motors. Each mill is provided with a dust collector with a capacity of 5,000 cubic feet a minute at a temperature of 180 deg. F. Water softeners are installed in the cooling-water system to prevent the formation of scale.

Cement Storage, Handling, and Packing.

Each of the four reinforced concrete cement silos has a capacity of 1,250 tons. The cement is extracted by airslides delivering to two 24-in. screw-conveyors, which in turn discharge to two elevators in the packing building; this is designed to contain two 12-spout packers, but at present only one packer is installed, and the second elevator is used for loading loose cement. The elevator delivers to a rotary screen, from which the cement passes through a pneumatic feeder to the packer, which fills paper bags at the rate of 120 tons per hour. A laminated conveyor takes the bags from the packer to a 36-in. flat-belt conveyor, which has throw-off knives to pass the bags to three retractable conveyors which load the lorries.

Burst bags are discharged over the end of the flat-belt conveyor into a hopper, where the cement is separated from the paper and is returned to the silos by a 3-in. pump. A dust-filter plant with a capacity of 6,800 cubic feet a minute is provided, and a vacuum plant with several suction points is provided for general cleaning purposes. Loose cement from the second elevator passes through the rotary screen and thence by means of 24-in. screw conveyors to two loading hoppers each with a capacity of 50 tons; road vehicles are loaded from these by means of airslides, dust being extracted by a unit with a rating of 2,000 cubic feet a minute.

Coal Preparation and Firing Plant.

Coal is extracted from the raw-coal bunker by a drag-link feeder, driven by a 3-h.p. motor through a hydraulic variable-speed gear, which delivers it to the coal mill; this machine weighs 19 tons and is of the static type. The overall height of the mill is 17 ft. and its diameter at the base about 6 ft.; it is operated by a 100-h.p. motor and has a rated output of $5\frac{1}{2}$ tons per hour with a residue of 12 per cent. on a 170-mesh sieve.

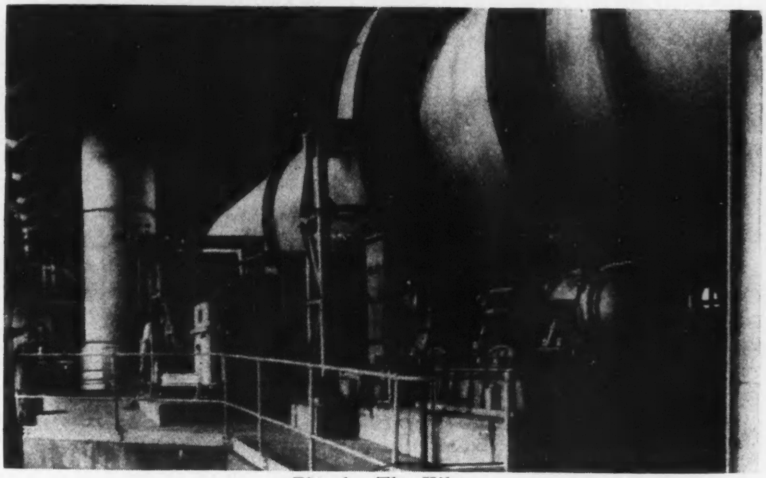

Fig. 6. The Kiln.

Hot air for the coal mill is taken from a port in the cooler through a duct which also supplies primary air to the " eye " of the firing fan. A cyclone is interposed to trap clinker dust. In order to maintain a satisfactory and constant temperature at the outlet of the mill, an automatically-controlled cold-air inlet is fitted to the duct immediately in front of the mill. The mill is airswept, the fine material being drawn into the filters at the top of the building by a 48-in. fan that can deal with 11,000 cubic feet of air a minute at 180 deg. F. and 33 in. water-gauge.

The filter plant consists of two circular six-compartment units with common inlet and outlet ducts. Each of the twelve compartments is isolated in turn, and the stockings scavenged by heated clean air moving in the reverse direction to the normal flow. Explosion reliefs of the membrane type occupy all the available space on the tops of the two castings, from which trunks extend through the roof so that, should an explosion occur, the gases may be dissipated clear of the building.

Pulverised fuel collected in the filters passes through two rotary feeders and a screw-conveyor to two hoppers of 30 tons capacity, one for kiln firing and the other for the raw mill furnaces. The hopper for the kiln is supported on three load cells to enable short-period checks to be made on coal consumption. Each hopper is discharged into a smaller constant-level feed hopper by a twin-screw extractor, which is automatically stopped and started by a pair of level-indicators.

The coal for the kiln is delivered from the feed hopper into the firing pipe by a rotary feeder having a variable-speed drive; the 54-in. firing fan is coupled directly to a 50-h.p. motor operating at 1,450 revolutions a minute. Pulverised fuel for the two raw-mill furnaces is extracted from the hopper by feeders and blown to the firing nozzle by pressure fans.

Power Supply, Motors, and Distribution.

Power is taken from the National Grid at 33 kV. and transformed to 3·3 kV. through two 4,000 kVA. transformers. The installed horse-power of plant is 9,500, and the estimated maximum demand is 4,600 kVA. There are four "heavy-load" areas, namely the limestone-crushing plant, the raw mills, the kiln plant, and the cement mills, in each of which is a 3·3 kVA. sub-station housing high-tension switchgear for motors of 200 h.p. and over, together with feeder circuit-breakers for six 750 kVA. 3,000/415 volt transformers and also low-tension distribution boards. All motors up to 90 h.p. are standardised. To a large extent sequence-control has been adopted to ensure correct starting sequences for machines in a group, and to reduce as far as practicable the consequences of the failure of a machine. Lighting throughout the works is at 110 volts, but the offices and laboratory are supplied at 230 volts.

Instruments.

The essential instruments for the operation of the raw-mill plant and the kiln group are centralised in panels, housed in pressurised cabins situated near the coal mills and on the kiln-firing platform. A further panel is located on the granulator floor. Pneumatic "power cylinders" are extensively used to provide remote control from the panels for dampers, motor-speed regulators, and so on; oil-free air for the cylinders is supplied by twin-cylinder compressors.

Administrative and Other Buildings.

The two-story office building has concrete floors and roof; the walls are of precast concrete blocks, faced with Cullamix Tyrolean finish. A single-story laboratory, with concrete-block walls and concrete floor and roof, is adjacent to the raw-meal blending plant and granulator building.

The stores and workshop building has two bays, in each of which is a hand-operated overhead travelling crane of 5 tons capacity.

Provision for Expansion.

Provision has been made for future addition of one or two more kilns.

The shale-crushing plant, the coal-crushing and handling plant, and the gypsum-intake plant already have sufficient capacity for operating two kilns. The limestone-crushing and handling plant would require the addition of one feeder, one conveyor, and another 5½-ft. cone crusher. The packing building is designed for another packer and space is available to permit the doubling of the present size of the raw-meal grinding, the blending, the storage, and the cement-grinding plant.

The works was designed by the Associated Portland Cement Manufacturers, Ltd., and Messrs. G. & T. Earle, Ltd. The civil engineering consultants were Messrs. Oscar Faber & Partners. The initial site clearance was done by Sir Alfred McAlpine & Sons, Ltd., who also laid much of the roads and paving. Messrs. George Wimpey & Co., Ltd., were the main civil engineering contractors. Messrs. Bierrum & Partners, Ltd., built the chimney and precipitators. Piling for the office and loading building was by Simplex Piling, Ltd. The structural steel was supplied and erected by Messrs. Redpath

Brown, Ltd., Techno Commercial, Ltd., and Messrs. Wright, Anderson & Co., Ltd. The erection of the machines was, in the main, carried out by the A.P.C.M., Ltd., and Messrs. G. & T. Earle, Ltd.

Among the suppliers of the plant were the following. Limestone crushers, made by Messrs. Fraser & Chalmers, Ltd., for Nordberg Manufacturing Co., Ltd. Limestone screens, made by Messrs. Stothert & Pitt, Ltd., for Nordberg Manufacturing Co., Ltd. Dust collectors in limestone crushing building, Visco Engineering Co., Ltd., Face-shovel for excavating limestone, Messrs. Ransome & Rapier, Ltd. Face-shovel for excavating shale, Ruston Bucyrus, Ltd. Hopper apron feeder and hammer-mill for shale, Messrs. Fraser & Chalmers, Ltd. Dust filter in shale-crushing plant and Lepol grate, Messrs. Polysius, Ltd. Apron-feeder for extracting crushed shale from bunker, Messrs. Ernest Newell & Co., Ltd. MB.22 mills, made by Pfeiffers to the design of Herr Max Berz. Furnaces for supplying hot air to MB. mills, Messrs. Alfred Herbert, Ltd. Pre-collector at MB mills, Messrs. Davidson & Co., Ltd. Electrostatic precipitator at MB mills, Sturtevant Engineering Co., Ltd. Redler conveyors and a Fuller-Kinyon pump and sampler are installed in the raw materials store. Fuller blending equipment, Fuller-Huron airslides and pumps, drag-chain conveyor, and Fuller-Kinyon pumps, Messrs. Constantin (Engineers), Ltd. Kiln, double-pass Fuller cooler, and clinker breaker, and cement-grinding mills, Vickers-Armstrongs (Engineers), Ltd. Fans for cooling clinker, Messrs. Keith, Blackman, Ltd. Coal mill, V. K. W., Dusseldorf. Coal-firing fan, Messrs. Keith, Blackman, Ltd. Dust-filter plant in packing department, Messrs. J. Darnley Taylor, Ltd. Transformers, Metropolitan Vickers Electrical Co., Ltd. Motors, English Electric Co., Ltd., Metropolitan Vickers Electrical Co., Ltd., British Thomson-Houston Co., Ltd., and Messrs. Laurence Scott. Screw-conveyors and elevators, Messrs. Barry, Henry & Cook, Ltd. Reduction gears, Messrs. David Brown & Sons, Ltd. Raw stone and coal grinding mills, P.H.I. Engineering, Ltd. Conveyor belting, Asbestos & Rubber Co. Shale conveyor system and feeder conveyors to raw stone mills, Messrs. Hugh Wood & Co., Ltd. Fluxo packer, Messrs. F. L. Smidth & Co., Ltd.

A Rotary Kiln in India.

We are informed by the Associated Cement Companies, Ltd., of Bombay, that a rotary kiln at their Kymore factory recently operated without interruption for 612 days, which is believed to be a world record considering that the refractory lining consisted of bricks with an alumina content of 45 to 50 per cent. The kiln was made in the companies' central workshop at Shahabad in the year 1948 and put into commission in January, 1949. The kiln operates on the wet process and is fitted with integral coolers. It has diameters of 10 ft., 9 ft., and 10 ft., and is 374 ft. long. The total production of clinker during the period was 189,980 long tons. The fuel was pulverised coal, the raw materials were sedimentary limestone and quarry overburden, and the water content of the slurry was 35 to 35·5 per cent. The composition of the clinker was: 43·63 per cent. C_3S; 30·64 per cent. C_2S; 9·45 per cent. C_3A; 10·33 per cent C_4AF. The lime-saturation factor was 0·88, and the silica modulus 2·44.

The Associated Cement Companies, Ltd., are the largest cement producers in India, having 15 factories in India and two in Pakistan. Their total annual production exceeds 3,250,000 tons, which it is proposed to increase to 5,500,000 tons by 1961.

Interaction between Aggregates and Cement.

THE BENEFICIAL EFFECT OF POZZOLANA.

OBSERVATIONS of the deterioration of concrete structures have led to the discovery during the last decade that this is sometimes caused by a chemical reaction, termed the "alkali reaction," between the alkalis present in the cement and certain aggregates. Most British aggregates are inert, but some European and American aggregates are not, and a committee was appointed in Denmark in 1953 to study the problem. Two interim reports* have been issued, from the second of which the following notes are abstracted.

Concrete made with Portland cement to which pozzolanic materials have been added is known to be resistant to chemical attack by sea-water. Such additives were used in Denmark by A. Poulsen, who put forward the theory, which is still accepted generally, that the chemical decomposition of concrete is caused by intruding $MgSO_4$ which, after reaction with $Ca(OH)_2$ and Al_2O_3, precipitates and gives rise to the formation of crystals of calcium sulphoaluminate, $3CaO, Al_2O_3\ 3Ca.SO_4, 31H_2O$. It is now known that such additives have a restraining effect on the alkali reaction which occurs between cement with a high content of alkali and aggregates containing soluble silica, when alkali hydroxide reacts with the silica and water to form an expansive gel. If sufficient water and alkali are present the gel is eventually transformed into a solution of alkali silicate.

The report states that the effect of pozzolanic additives may be represented as follows. During the hydration of tricalcuim silicate and aluminate fairly large quantities of calcium-crystalline hydroxide are liberated, which are deposited in the cement gel. These $Ca(OH)_2$ crystals do not contribute to the cementing of the gel, but SiO_2 and Al_2O_3 (pozzolana) complexes are formed by their reaction with any pulverized reactive agent which may be present. These complexes are similar in composition to those resulting from the hydration of cement, and the efficiency of the cement is thereby increased. Part of the alkali hydroxide that has entered into the reaction is retained and bound in non-swelling gels, and is therefore removed from the solution. Consequently the Ca^{++} concentration in agreement with the solubility product for $Ca(OH)_2$ increases with decreasing OH^- concentration, and the conditions near the surface of particles of coarse reactive aggregate are such that the penetrative tendencies of Ca^{++} and Na^+ (K^+) are disturbed in favour of Ca^{++}. The complexes formed by particles of aggregate with CaO and $Na_2O.(K_2O)$ will therefore be of a non-swelling nature. The penetration of the Ca^{++} ions is thought to consist of a surface diffusion on the inside of the pores in the primary alkali-silica gel. Whether this expansive gel is transformed into non-swelling gel by the addition of sufficient Ca^{++} in competition with Na^+ (K^+) depends on the concentration gradient for Ca^{++}, which increases with the Ca^{++} concentration in the solution, and decreases with the diffusion distance (which depends upon the particle size).

The formation of non-swelling gels on the surface of particles of reactive

aggregate may consequently occur, and expansive reactions may be avoided, if the OH $^-$ concentration is kept below a maximum limit, either as a result of reaction with pozzolana, or because the original content of alkali in the cement is sufficiently low. An increase in the surface area of the total reactive material, obtained by diminishing the sizes of the particles, may also impede alkali reactions.

Tests are being carried out on pozzolanic materials available in Denmark in reasonable quantities, but no reliable quantitative results are yet available. The natural pozzolanic materials being tested are porous opal, porous chalcedony, limestone-opal flint, calcium silicate, kieselguhr, Refsnæs clay, kaolin, moler, and quartz. The most suitable of these have been found to be limestone-opal flint, kieselguhr, kaolin, and moler. The artificial materials tested are "Si-stoff" (the residuum after Al_2O_3 is extiacted with HCl from calcined clay minerals), " Aerosil " (a silica hydrate), and əshes from incinerators, and of tbese only " Si-stoff " was found to be suitable.

*Committee on Alkali Reactions in Concrete. Progress Reports N.1 (1956) " Disintegration of Field Concrete," by G. M. Idorn, and L.1 (1957) " Investigation of the Effect of Some Pozzolans on Alkali Reactions in Concrete," by A. H. M. Andreasen and K. E. Haulund Christensen. Copenhagen: Danish National Institute of Building Research. Price 12 Kroner each. Printed in the English langauge.

The Hydration of Cement.

In the annual report of the Building Research Station (" Building Research 1956," H.M. Stationery Office. Price 5*s*. 6*d*.) it is stated that further work on the system lime-alumina-water indicates that, although there is only one form of the tetra-calcium aluminate hydrate $4CaO.Al_2O_3.19H_2O$ in the aqueous system, two forms of the dicalcium aluminate hydrate $2CaO.Al_2O_3.8H_2O$ may be precipitated from solution. The normal α-form shows in X-ray patterns a longest basal spacing of 10·7°Å, but another, less stable, β-form with a longest basal spacing of 10·4°Å sometimes appears at an invariant point with alumina gel. Other hydrates and/or polymorphs, formed on drying under various conditions, do not exist in the aqueous phase and are therefore of only indirect interest. A solubility curve has been established for the hydrate $4CaO.Al_2O_3.19H_2O$ and for what appears to be a " solid solution " series over a restricted range of lime-alumina ratios in the solid phase from 2·0 to 2·4, extending from an unstable invariant point (alumina gel—$2CaO.Al_2O_3.8H_2O$) to an invariant point (" solid solution "—$4CaO.Al_2O_3.19H_2O$).

The Cement Industry in Colombia.

Licences have been issued for the importation into Colombia of the plant for new cement works to be built at Boyaca, Caldas, and Tolima.

New Cement Works in Denmark.

A new cement works is being built at Karlstrup, near Køge, Denmark, for the Aalborg Portland Cement Co. The capacity will be 3,000,000 sacks of cement a year, and it is expected that production will start in May next year.

Production of Cement in the Belgian Congo.

The production of cement in the Belgian Congo in the year 1956 was 459,000 tons.

Proposed New Cement Works in India.

The Government of India has issued licences to the following firms for the erection of new cement works and the extension of existing works. The name of the firm is followed by the location of the proposed works and the annual capacity.

Kuchwar Lime & Co., 22 Canning Street, Calcutta. Durgapur, West Bengal. 240,000 tons.

Andhra Cement Co., Ltd., 337 Thambu Chetty Street, G.T., Madras. Vijayawada (Andhra). 33,000 tons.

Digvijaya Cement Co., Ltd., Shree Nivas House, Waudby Road, Bombay. Sikka, Bombay. 200,000 tons.

Sone Valley Portland Cement Co., Ltd., 31 Chittaranjan Avenue, Calcutta 12. Japla District, Palamau (Bihar). 231,000 tons.

New Cement Works in the Phillipines.

A new cement works, built by the Republic Cement Co., started operation in July last; its capacity is 10,000 bags of cement a day.

New Cement Works in Peru.

The new cement works at Pacasmayo of the Compania de Cemento Pacasmayo S.A. is now completed; its capacity is 100,000 tons a year. The equipment was supplied by two West German firms, namely, M.I.A.G. and Siemens. Several other cement works are under construction in Peru, or being planned.

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